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(54) **CONTINUOUS ENROLLMENT FOR FACE VERIFICATION**

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H04N 5/232 (2006.01)

(52) **U.S. Cl.**
CPC ***G06K 9/00288*** (2013.01); ***H04N 5/23229*** (2013.01)

(58) **Field of Classification Search**
CPC .. G06F 21/31; G06F 17/30598; G06F 21/00; G06F 3/1292; G06F 21/32; G06F 17/30554; G06F 17/30424; G06K 9/00221; G06K 9/00288; G06K 9/00268; G06K 9/00302; G06K 9/00711
USPC 382/118
See application file for complete search history.

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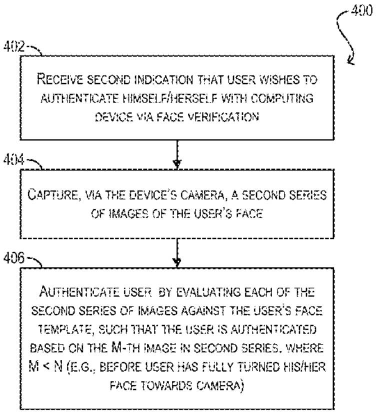
(57) **ABSTRACT**

Techniques for performing continuous enrollment for face verification are provided. In one embodiment, a computing device can receive, from a user, an indication that the user wishes to authenticate himself/herself with the computing device via face verification. In response to the indication, the computing device can capture, using a camera, a series of images of the user's face and can authenticate the user by evaluating each of the series of images against a face template for the user, where the user is authenticated based on an N-th image in the series. Once the user has been authenticated, the computing device can select one or more images from the series prior to the N-th image and can add the selected images to the user's face template.

33 Claims, 5 Drawing Sheets


400
402
RECEIVE SECOND INDICATION THAT USER WISHES TO AUTHENTICATE HIMSELF/HERSELF WITH COMPUTING DEVICE VIA FACE VERIFICATION
404
CAPTURE, VIA THE DEVICE'S CAMERA, A SECOND SERIES OF IMAGES OF THE USER'S FACE
406
AUTHENTICATE USER BY EVALUATING EACH OF THE SECOND SERIES OF IMAGES AGAINST THE USER'S FACE TEMPLATE, SUCH THAT THE USER IS AUTHENTICATED BASED ON THE M-TH IMAGE IN SECOND SERIES, WHERE M < N (E.G., BEFORE USER HAS FULLY TURNED HIS/HER FACE TOWARDS CAMERA)

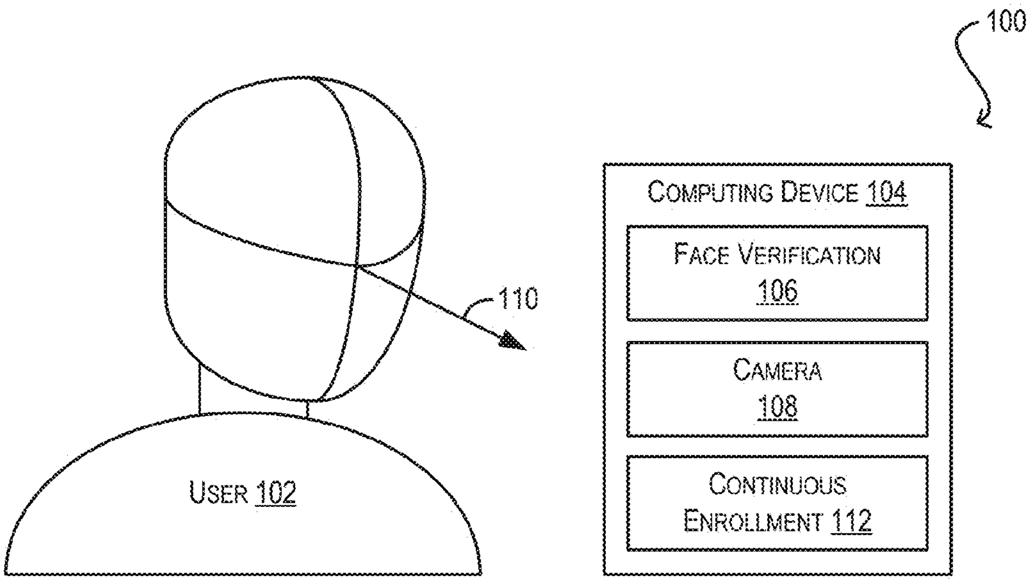

100
110
User 102
Computing Device 104
Face Verification 106
Camera 108
Continuous Enrollment 112

FIG. 1

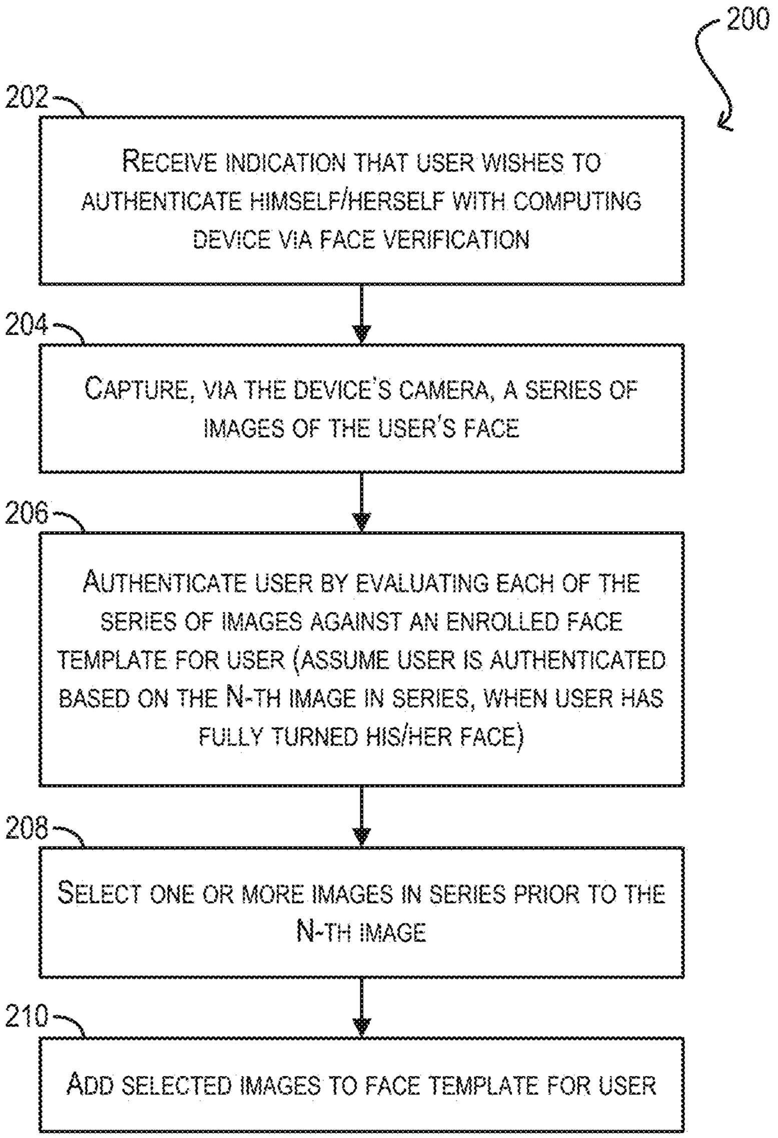

200
202
RECEIVE INDICATION THAT USER WISHES TO AUTHENTICATE HIMSELF/HERSELF WITH COMPUTING DEVICE VIA FACE VERIFICATION
204
CAPTURE, VIA THE DEVICE'S CAMERA, A SERIES OF IMAGES OF THE USER'S FACE
206
AUTHENTICATE USER BY EVALUATING EACH OF THE SERIES OF IMAGES AGAINST AN ENROLLED FACE TEMPLATE FOR USER (ASSUME USER IS AUTHENTICATED BASED ON THE N-TH IMAGE IN SERIES, WHEN USER HAS FULLY TURNED HIS/HER FACE)
208
SELECT ONE OR MORE IMAGES IN SERIES PRIOR TO THE N-TH IMAGE
210
ADD SELECTED IMAGES TO FACE TEMPLATE FOR USER

FIG. 2

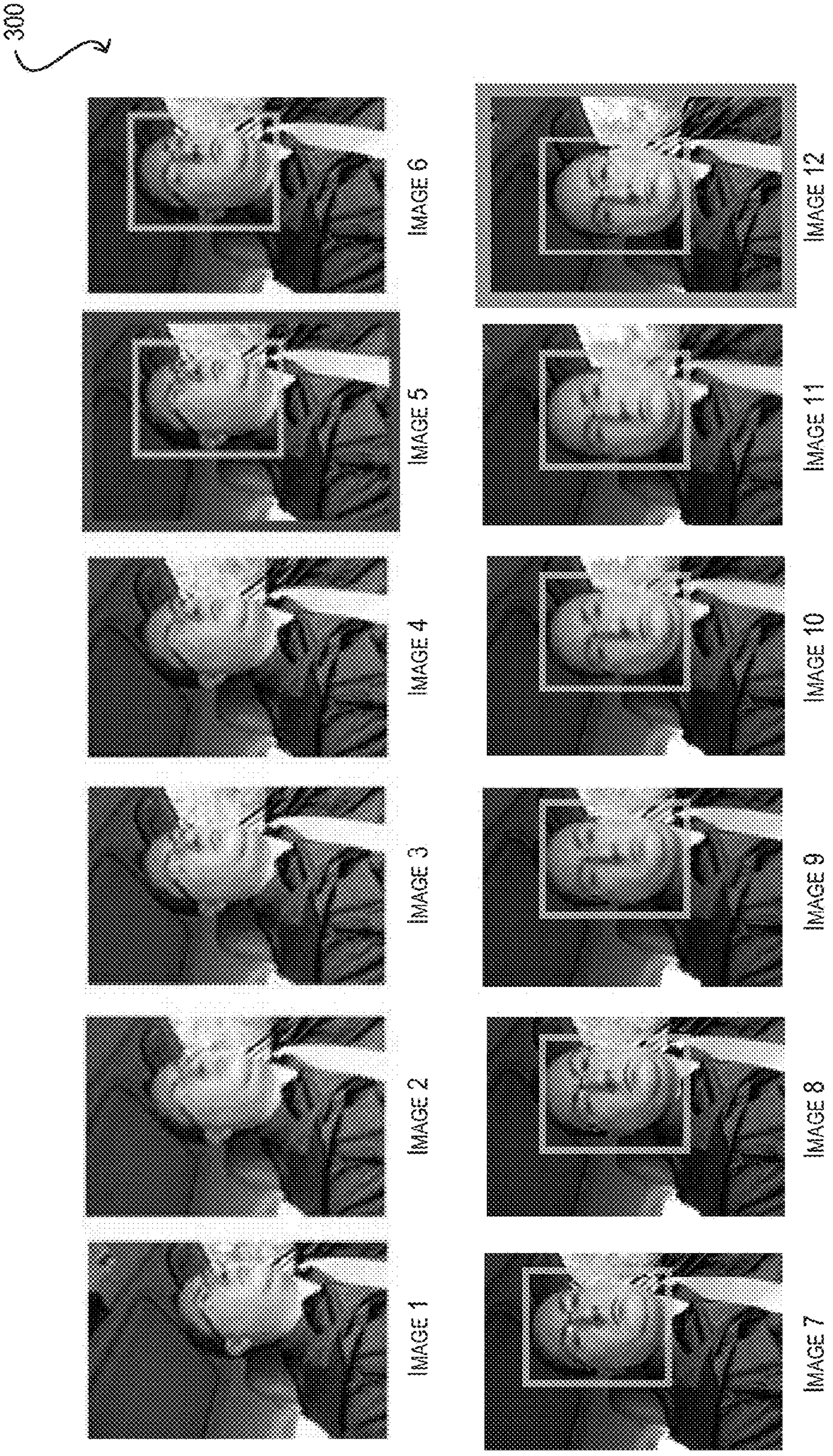

300
IMAGE 1
IMAGE 2
IMAGE 3
IMAGE 4
IMAGE 5
IMAGE 6
IMAGE 7
IMAGE 8
IMAGE 9
IMAGE 10
IMAGE 11
IMAGE 12

FIG. 3

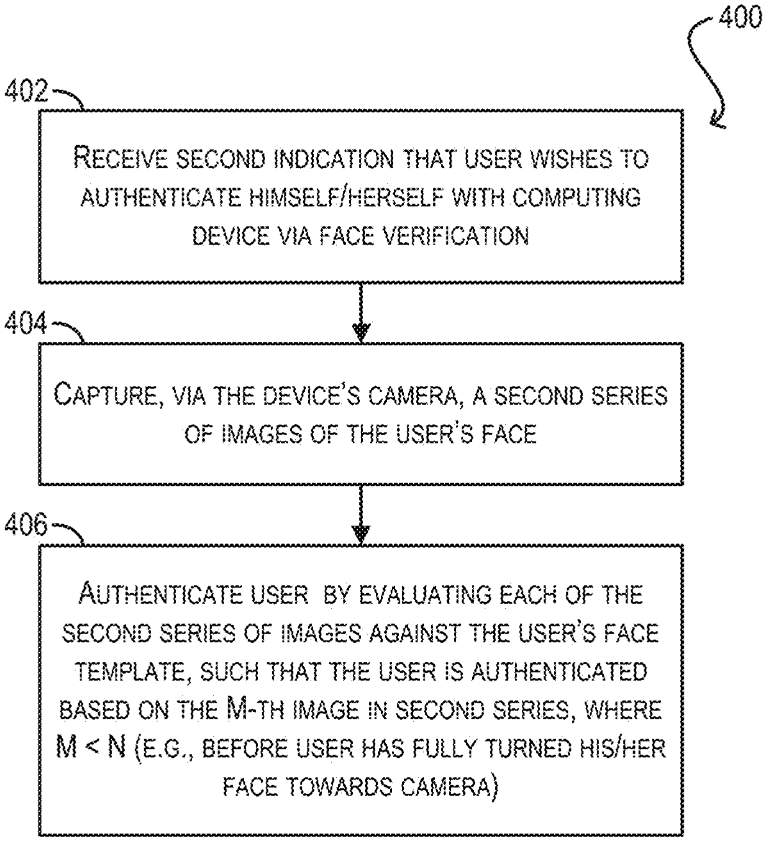

400
402
RECEIVE SECOND INDICATION THAT USER WISHES TO AUTHENTICATE HIMSELF/HERSELF WITH COMPUTING DEVICE VIA FACE VERIFICATION
404
CAPTURE, VIA THE DEVICE'S CAMERA, A SECOND SERIES OF IMAGES OF THE USER'S FACE
406
AUTHENTICATE USER BY EVALUATING EACH OF THE SECOND SERIES OF IMAGES AGAINST THE USER'S FACE TEMPLATE, SUCH THAT THE USER IS AUTHENTICATED BASED ON THE M-TH IMAGE IN SECOND SERIES, WHERE M < N (E.G., BEFORE USER HAS FULLY TURNED HIS/HER FACE TOWARDS CAMERA)

FIG. 4

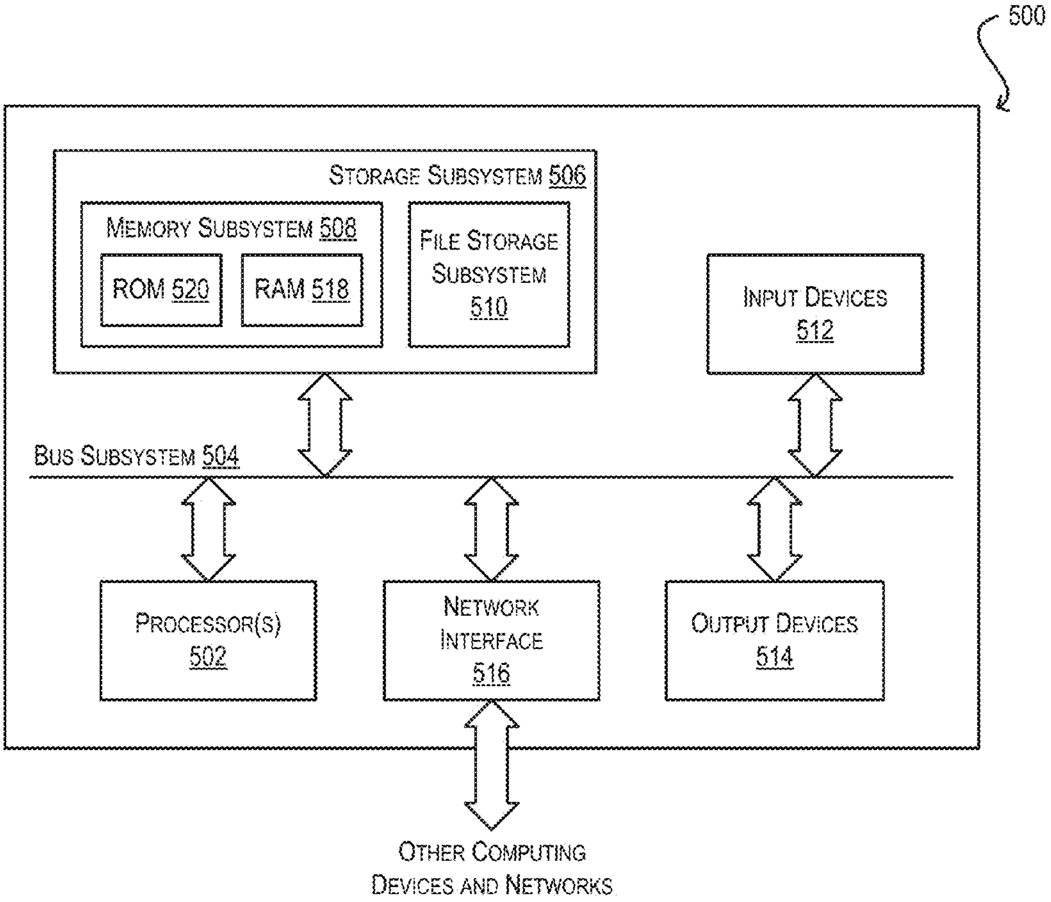

500
Storage Subsystem 506
Memory Subsystem 508
ROM 520
RAM 518
File Storage Subsystem 510
Input Devices 512
Bus Subsystem 504
Processor(s) 502
Network Interface 516
Output Devices 514
Other Computing Devices and Networks

FIG. 5

CONTINUOUS ENROLLMENT FOR FACE VERIFICATION

BACKGROUND

With the proliferation of cameras in computing devices such as smartphones, tablets, laptop computers, and the like, it has become increasingly common for such devices to implement face verification systems (also known as face recognition systems) for user authentication. In a conventional face verification system, a device user is typically required to complete an initial enrollment process in which the user is instructed to look squarely at the device's camera, thereby allowing the camera to capture one or more frontal view images of the user's face. The face verification system uses these frontal view image(s) to generate a face template for the user. The face verification system can then compare the face template to images of the user's face that are captured at the point of authentication in order to verify the user's identity.

One problem with the conventional approach above is that, since the enrolled face template relies solely on frontal view images of the user's face, the user must generally look at the device's camera straight-on (i.e., using the same frontal pose used during the enrollment process) at the time he/she wishes to be authenticated. If the user positions his/her face in a manner that is not square with the camera (referred to herein as an "off-pose" position), the authentication is more likely to fail, or at least be delayed until the user turns his/her face into a square position, because the face template does not have any data representing the sides of the user's face. A workaround for this problem is to capture multiple facial poses from the user during the enrollment process by, e.g., instructing the user to look left, right, up, and/or down (in addition to straight-on). However, this workaround makes the enrollment process cumbersome and unnatural for the user. In addition, the captured facial poses may still not reflect the actual poses that the user will present when attempting to authenticate himself/herself, and thus may not result in more accurate or more rapid authentication outcomes.

SUMMARY

Techniques for performing continuous enrollment for face verification are provided. In one embodiment, a computing device can receive, from a user, an indication that the user wishes to authenticate himself/herself with the computing device via face verification. In response to the indication, the computing device can capture, using a camera, a series of images of the user's face and can authenticate the user by evaluating each of the series of images against a face template for the user, where the user is authenticated based on an N-th image in the series. Once the user has been authenticated, the computing device can select one or more images from the series prior to the N-th image and can add the selected images to the user's face template.

A further understanding of the nature and advantages of the embodiments disclosed herein can be realized by reference to the remaining portions of the specification and the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a system environment according to an embodiment.

FIG. **2** depicts a first workflow for enabling continuous enrollment for face verification according to an embodiment.

FIG. **3** depicts a series of images captured per the workflow of FIG. **2** according to an embodiment.

FIG. **4** depicts a second workflow for enabling continuous enrollment for face verification according to an embodiment.

FIG. **5** depicts a computing device according to an embodiment.

DETAILED DESCRIPTION

In the following description, for purposes of explanation, numerous examples and details are set forth in order to provide an understanding of specific embodiments. It will be evident, however, to one skilled in the art that certain embodiments can be practiced without some of these details, or can be practiced with modifications or equivalents thereof.

1. Overview

The present disclosure describes techniques that can be implemented by a computing device for performing continuous enrollment of device users for face verification. These techniques are premised on the notion that, at the time of authentication, a user will typically turn or rotate his/her face from an off-pose position to a straight-on (i.e., square) position with respect to the device's camera in order to authenticate himself/herself. In one set of embodiments, while the user is turning his/her face, the computing device can capture and buffer a series of images of the user's face in these off-pose positions. At the moment the user is successfully authenticated (e.g., when the user has fully turned his/her face towards the device's camera), the computing device can look back in time at the previously captured/buffered images and can automatically add one or more of those images to the user's face template. In this way, the off-pose positions that the user presented while (or before) turning toward the camera can be incorporated into the face template. Then, the next time the user attempts to authenticate himself/herself via face verification in a similar setting, the computing device can authenticate the user without requiring the user to fully turn towards the camera (since the face template now has data for the user's off-pose position(s)).

With the approach above, there is no need for the user to provide explicit enrollment data for the off-pose positions; instead, the user can participate in a conventional enrollment process where he/she only looks squarely at the device camera, and the computing device can dynamically capture off-pose information at the time of authentication, without the user's knowledge or input. Thus, there is no additional burden on the user when compared to existing face verification approaches.

At the same time, this approach can significantly improve authentication time and accuracy, assuming that the off-pose positions presented by the user are similar for each authentication event. For example, consider a scenario where the user is sitting in a vehicle with the computing device placed in a fixed location (e.g., a car cup-holder). In this scenario, the relative positioning of the user and the computing device will remain the same each time the user wishes to authenticate himself/herself, and thus the off-pose positions presented by the user will generally be consistent. This, in turn, means that the user's face template (which is updated to include the user's off-pose information after a first authentication attempt) can be used to immediately authenticate the user on the second and subsequent authentication attempts, before the user turns to look at the device's camera. Note that this immediate authentication has the additional benefit of allowing the user to keep his/her gaze on the road if the user is the vehicle driver.

The foregoing and other aspects of the present invention are described in further detail in the sections that follow.

2. System Environment

FIG. **1** depicts a system environment **100** that supports continuous enrollment for face verification according to an embodiment. As shown, system environment **100** includes a user **102** and a computing device **104**. Computing device **104** can be any type of electronic device that is capable of (either alone or in conjunction with other devices/systems) verifying user **102**'s identity based on his/her face. In one embodiment, computing device **104** can be a handheld device, such as a smartphone, a tablet, a smartwatch, or the like. In other embodiments, computing device **104** can be a larger device or system, such as a desktop computer, a kiosk or ATM machine, an in-vehicle computer system, etc. To carry out its face verification processing, computing device **104** can include a face verification module **106** and a camera **108**.

As noted in the Background section, one drawback with existing face verification systems is that they generally rely on a static enrollment process in which a device user is instructed to look straight-on at the device's camera, thereby generating a face template that is based solely on a frontal view of the user's face. For instance, in the example of FIG. **1**, user **102** would be instructed to look straight-on at camera **108** (shown by directional arrow **110**). This means that, at the point of authentication, the user must present substantially the same frontal pose to the device in order to be successfully authenticated, since the face template does not have any data for off-pose positions of the user's face.

To address the foregoing and other similar issues, computing device **104** of FIG. **1** can include a novel continuous enrollment module **112**. In various embodiments, continuous enrollment module **112** can be implemented as software that is executed by, e.g., a general-purpose processor of computing device **104**, as a dedicated hardware component, or as a combination of software and hardware. As described in further detail below, computing device **104** can leverage module **112** to continuously learn off-pose positions that are presented by user **102** at the point of authentication, and can dynamically update user **102**'s face template based on those learned positions. This, in turn, can enable face verification module **106** to more accurately and quickly authenticate user **102** in situations where his/her facial pose may not be square with camera **108**. For example, in certain embodiments, face verification module **106** can authenticate user **102** immediately upon initiating the authentication process, before the user has even had a chance to turn his/her face towards camera **108**.

3. Workflows

FIG. **2** depicts an authentication workflow **200** that can be performed by computing device **104** with respect to user **102** for enabling continuous enrollment according to an embodiment. Workflow **200** assumes that computing device **104** has already created, via an initial enrollment process, a face template for user **102** that is solely based on a frontal view of user **102**'s face.

At block **202**, computing device **104** can receive an indication that user **102** wishes to authentication himself or herself with the device via face verification. Computing device **104** can receive this indication in various different formats, such as a button press, a voice command, a hand motion/movement, etc.

Upon receiving the indication at block **202**, computing device **104** can begin capturing, via camera **108**, a series of images of user **102**'s face (block **204**). In a particular embodiment, this can involve taking photos or a video of the field of view in front of camera **108** and applying a face detection algorithm to detect a face in the captured photos/or video. The photos or video frames with a detected face can be considered candidate images for consideration by face verification module **106** and can be buffered by computing device **104** in a temporary memory.

At block **206**, face verification module **106** can evaluate each of the candidate images captured/buffered at block **204** against the enrolled face template for user **102** and can authenticate the user based on the N-th image in the series. As noted previously, it is assumed that the face template initially includes data for only a frontal view of user **102**'s face. Thus, the N-th image will generally be an image where user **102** has fully turned his/her face towards camera **108**.

Finally, at blocks **208** and **210**, continuous enrollment module **112** can select one or more images in the series prior to the N-th image and can add the selected image(s) to user **102**'s face template, thereby dynamically updating the template. The rationale behind these steps is that, before the Nth-image, user **102** was likely in the process of turning his/her face towards camera **108** in order to be authenticated. Thus, by adding one or more images prior to the N-th image to user **102**'s face template, continuous enrollment module **112** can automatically enhance the face template to detect these off-pose positions. Face verification module **106** can then use the enhanced face template during a subsequent authentication attempt to authenticate user **102** while user **102**'s face is still in an off-pose position (e.g., before he/she has turned to look at camera **108**), thereby speeding up the authentication process.

It should be appreciated that the particular manner in which the prior images are selected at block **208** can vary. For example, in one embodiment, continuous enrollment module **112** can select the first image in the candidate series. In another embodiment, continuous enrollment module **112** can select all of the N−1 images in the series prior to the N-th image. In yet another embodiment, continuous enrollment module **112** can calculate a measure of similarity (e.g., distance similarity) between each of the series of images and the face template, and can select the images that are closest to the face template. One of ordinary skill in the art will recognize other variations, modifications, and alternatives for the selection processing at block **208**.

To clarify the operation of workflow **200**, FIG. **3** depicts an exemplary series of images **300** that may be captured by computing device **104** per workflow **200** according to an embodiment. In the example of FIG. **3**, the user is depicted within an in-vehicle environment, although the techniques of the present invention may also apply to other environments.

As shown, starting with image **1**, computing device **104** begins capturing images in its field of view. Note that the user has not yet begun turning his face towards the camera. At image **5**, device **104** detects a face within the image frame (shown by the yellow border). Thus, image **5** can be considered the first image in the series of candidate images to be evaluated by face verification module **106**, and device **104** can begin buffering the images at this point.

At images **5** through **11**, the user gradually turns his head towards camera **108** for authentication. At image **12**, the user's face is square enough with camera **108** for face verification module **106** to authenticate the user based on the user's initial face template. This authentication moment is shown by the green border around image **12**.

In response to the authentication performed with respect to image **12**, continuous enrollment module **112** goes back though previously buffered images **5-11** and selects one or more of the buffered images for inclusion in the user's face template. In this specific example, continuous enrollment module **112** selects image **5** (shown by the red border). Continuous enrollment module **112** then adds image **5** to the face template, thereby allowing computing device **104** to verify the user's identity on a subsequent authentication attempt based on the facial pose shown in image **5** (rather than having to wait for the user to fully turn his face towards the camera as in image **12**).

FIG. **4** depicts a workflow **400** that can be performed by computing device **104** for authenticating user **102** on a second authentication attempt (i.e., after the user's face template has been updated per workflow **200** of FIG. **2**) according to an embodiment. Starting with block **402**, computing device **104** can receive a second indication that user **102** wishes to authenticate himself or herself with the device via face verification.

At block **404**, computing device **104** can capture, via camera **108**, a second series of images of user **102**'s face. This processing can be similar to block **204** of FIG. **2**.

Then, at block **406**, face verification module **108** can evaluate each of the second series of images captured at block **404** against the face template for user **102** and can authenticate the user based on the M-th image in the series, where M is less than N. For instance, image M may be an image of user **102**'s face before he/she has fully turned to look at camera **108** (e.g., image **5** in FIG. **3**). This is made possible by the fact that user **102**'s face template has been updated (per block **210** of FIG. **2**) to include data for this off-pose position. The end result of this processing is that user **102** is authenticated at a significantly earlier point in time when compared to the first authentication attempt of FIG. **2**.

4. Exemplary Computing Device

FIG. **5** is a simplified block diagram of a computing device **500** that may be used to implement the foregoing embodiments of the present invention. As shown, computing device **500** includes one or more processors **502** that communicate with a number of peripheral devices via a bus subsystem **504**. These peripheral devices include a storage subsystem **506** (comprising a memory subsystem **508** and a file storage subsystem **510**), input devices **512**, output devices **514**, and a network interface subsystem **516**.

Bus subsystem **504** can provide a mechanism for letting the various components and subsystems of computing device **500** communicate with each other as intended. Although bus subsystem **504** is shown schematically as a single bus, alternative embodiments of the bus subsystem can utilize multiple buses.

Network interface subsystem **516** can serve as an interface for communicating data between computing device **500** and other computing devices or networks. Embodiments of network interface subsystem **516** can include wired (e.g., coaxial, twisted pair, or fiber optic Ethernet) and/or wireless (e.g., Wi-Fi, cellular, Bluetooth, etc.) interfaces.

Input devices **512** can include a camera (such as camera **108** of FIG. **1**), a touch-screen incorporated into a display, a keyboard, a pointing device (e.g., mouse, touchpad, etc.), an audio input device (e.g., a microphone), and/or other types of input devices. In general, use of the term "input device" is intended to include all possible types of devices and mechanisms for inputting information into computing device **500**.

Output devices **514** can include a display subsystem (e.g., a flat-panel display), an audio output device (e.g., a speaker), and/or the like. In general, use of the term "output device" is intended to include all possible types of devices and mechanisms for outputting information from computing device **500**.

Storage subsystem **506** includes a memory subsystem **508** and a file/disk storage subsystem **510**. Subsystems **508** and **510** represent non-transitory computer-readable storage media that can store program code and/or data that provide the functionality of various embodiments described herein.

Memory subsystem **508** can include a number of memories including a main random access memory (RAM) **518** for storage of instructions and data during program execution and a read-only memory (ROM) **520** in which fixed instructions are stored. File storage subsystem **510** can provide persistent (i.e., non-volatile) storage for program and data files and can include a magnetic or solid-state hard disk drive, an optical drive along with associated removable media (e.g., CD-ROM, DVD, Blu-Ray, etc.), a removable flash memory-based drive or card, and/or other types of storage media known in the art.

It should be appreciated that computing device **500** is illustrative and not intended to limit embodiments of the present invention. Many other configurations having more or fewer components than computing device **500** are possible.

The above description illustrates various embodiments of the present invention along with examples of how aspects of the present invention may be implemented. The above examples and embodiments should not be deemed to be the only embodiments, and are presented to illustrate the flexibility and advantages of the present invention as defined by the following claims. For example, although certain embodiments have been described with respect to particular process flows and steps, it should be apparent to those skilled in the art that the scope of the present invention is not strictly limited to the described flows and steps. Steps described as sequential may be executed in parallel, order of steps may be varied, and steps may be modified, combined, added, or omitted.

Further, although certain embodiments have been described using a particular combination of hardware and software, it should be recognized that other combinations of hardware and software are possible, and that specific operations described as being implemented in software can also be implemented in hardware and vice versa.

The specification and drawings are, accordingly, to be regarded in an illustrative rather than restrictive sense. Other arrangements, embodiments, implementations and equivalents will be evident to those skilled in the art and may be employed without departing from the spirit and scope of the invention as set forth in the following claims.

What is claimed is:

1. A method comprising:

receiving, by a computing device from a user, a first indication that the user wishes to authenticate himself or herself with the computing device via face verification;

in response to the first indication, capturing, by the computing device using a camera, a first series of images of the user's face;

authenticating, by the computing device, the user by evaluating each of the first series of images against a face template for the user, wherein the user is authenticated based on an N-th image in the first series;

selecting, by the computing device, one or more images from the first series prior to the N-th image;

adding, by the computing device, the one or more images to the face template for the user;

at a later point in time, receiving, by the computing device from the user, a second indication that the user wishes to authenticate himself or herself with the computing device via face verification;

in response to the second indication, capturing, by the computing device using the camera, a second series of images of the user's face; and

authenticating, by the computing device, the user by evaluating each of the second series of images against the face template for the user, wherein the user is authenticated based on an M-th image in the second series, and wherein M is less than N.

2. The method of claim **1** wherein the face template is based on one or more enrolled images of the user's face, and wherein the one or more enrolled images solely comprise a frontal view of the user's face.

3. The method of claim **1** wherein, in the one or more images selected from the first series, the user's face is turned away from the camera.

4. The method of claim **1** wherein the computing device buffers the first series of images as part of the capturing.

5. The method of claim **1** wherein the user's face is turned away from the camera in the M-th image.

6. The method of claim **1** wherein the user is authenticated based on the M-th image because the user's facial pose in the M-th image matches one of the one or more images selected from the first series.

7. The method of claim **1** wherein selecting the one or more images comprises selecting the first image in the first series.

8. The method of claim **1** wherein selecting the one or more images comprises selecting the N-**1** images in the first series prior to the N-th image.

9. The method of claim **1** wherein selecting the one or more images comprises:

calculating a measure of similarity between each of the first series of images and the face template; and

selecting the one or more images based on the measures of similarity.

10. The method of claim **1** wherein the user is situated within a vehicle, and wherein the computing device is a mobile device that is placed in a stationary position, relative to the user, in the vehicle.

11. A non-transitory computer readable medium having stored thereon program code executable by a processor of a computing device, the program code comprising:

code that causes the processor to receive, from a user, a first indication that the user wishes to authenticate himself or herself with the computing device via face verification;

in response to the first indication, code that causes the processor to capture, using a camera of the computing device, a first series of images of the user's face;

code that causes the processor to authenticate the user by evaluating each of the first series of images against a face template for the user, wherein the user is authenticated based on an N-th image in the first series;

code that causes the processor to select one or more images from the first series prior to the N-th image;

code that causes the processor to add the one or more images to the face template for the user;

code that causes the processor to receive, from the user at a later point in time, a second indication that the user wishes to authenticate himself or herself with the computing device via face verification;

code that causes the processor to capture, using the camera, a second series of images of the user's face in response to the second indication; and

code that causes the processor to authenticate the user by evaluating each of the second series of images against the face template for the user, wherein the user is authenticated based on an M-th image in the second series, and wherein M is less than N.

12. The non-transitory computer readable medium of claim **11** wherein the face template is based on one or more enrolled images of the user's face, and wherein the one or more enrolled images solely comprise a frontal view of the user's face.

13. The non-transitory computer readable medium of claim **11** wherein, in the one or more images selected from the first series, the user's face is turned away from the camera.

14. The non-transitory computer readable medium of claim **11** wherein the processor buffers the first series of images in an associated memory as part of the capturing.

15. The non-transitory computer readable medium of claim **11** wherein the user's face is turned away from the camera in the M-th image.

16. The non-transitory computer readable medium of claim **11** wherein the user is authenticated based on the M-th image because the user's facial pose in the M-th image matches one of the one or more images selected from the first series.

17. The non-transitory computer readable medium of claim **11** wherein the code that causes the processor to select the one or more images comprises code that causes the processor to select the first image in the first series.

18. The non-transitory computer readable medium of claim **11** wherein the code that causes the processor to select the one or more images comprises code that causes the processor to select the N−1 images in the first series prior to the N-th image.

19. The non-transitory computer readable medium of claim **11** wherein the code that causes the processor to select the one or more images comprises:

code that causes the processor to calculate a measure of similarity between each of the first series of images and the face template; and

code that causes the processor to select the one or more images based on the measures of similarity.

20. The non-transitory computer readable medium of claim **11** wherein the user is situated within a vehicle, and wherein the computing device is a mobile device that is placed in a stationary position, relative to the user, in the vehicle.

21. A computing device comprising:

a memory;

a camera;

a processor; and

a non-transitory computer readable medium having stored thereon program code which, when executed by the processor, causes the processor to:

receive, from a user, a first indication that the user wishes to authenticate himself or herself with the computing device via face verification;

in response to the first indication, capture, using the camera, a first series of images of the user's face;

authenticate the user by evaluating each of the first series of images against a face template for the user, wherein the user is authenticated based on an N-th image in the first series;

select one or more images from the first series prior to the N-th image;

add the one or more images to the face template for the user;

receive, from the user at a later point in time, a second indication that the user wishes to authenticate himself or herself with the computing device via face verification;

in response to the second indication, capture, using the camera, a second series of images of the user's face; and

authenticate the user by evaluating each of the second series of images against the face template for the user, wherein the user is authenticated based on an M-th image in the second series, and wherein M is less than N.

22. The computing device of claim **21** wherein the face template is based on one or more enrolled images of the user's face, and wherein the one or more enrolled images solely comprise a frontal view of the user's face.

23. The computing device of claim **21** wherein, in the one or more images selected from the first series, the user's face is turned away from the camera.

24. The computing device of claim **21** wherein the processor buffers the first series of images in the memory as part of the capturing.

25. The computing device of claim **21** wherein the user's face is turned away from the camera in the M-th image.

26. The computing device of claim **21** wherein the user is authenticated based on the M-th image because the user's facial pose in the M-th image matches one of the one or more images selected from the first series.

27. The computing device of claim **21** wherein the program code that causes the processor to select the one or more images causes the processor to select the first image in the first series.

28. The computing device of claim **21** wherein the program code that causes the processor to select the one or more images causes the processor to select the N-**1** images in the first series prior to the N-th image.

29. The computing device of claim **21** wherein the program code that causes the processor to select the one or more images causes the processor to:

calculate a measure of similarity between each of the first series of images and the face template; and

select the one or more images based on the measures of similarity.

30. The computing device of claim **21** wherein the user is situated within a vehicle, and wherein the computing device is a mobile device that is placed in a stationary position, relative to the user, in the vehicle.

31. A method comprising:

receiving, by a computing device from a user, a first indication that the user wishes to authenticate himself or herself with the computing device via face verification;

in response to the first indication, capturing, by the computing device using a camera, a first series of images of the user's face;

authenticating, by the computing device, the user by evaluating each of the first series of images against a face template for the user, wherein the user is authenticated based on an N-th image in the first series;

selecting, by the computing device, one or more images from the first series prior to the N-th image, the selecting comprising:

calculating a measure of similarity between each of the first series of images and the face template; and

selecting the one or more images based on the measures of similarity; and

adding, by the computing device, the one or more images to the face template for the user.

32. A non-transitory computer readable medium having stored thereon program code executable by a processor of a computing device, the program code comprising:

code that causes the processor to receive, from a user, a first indication that the user wishes to authenticate himself or herself with the computing device via face verification;

in response to the first indication, code that causes the processor to capture, using a camera of the computing device, a first series of images of the user's face;

code that causes the processor to authenticate the user by evaluating each of the first series of images against a face template for the user, wherein the user is authenticated based on an N-th image in the first series;

code that causes the processor to select one or more images from the first series prior to the N-th image by:

calculating a measure of similarity between each of the first series of images and the face template; and

selecting the one or more images based on the measures of similarity; and

code that causes the processor to add the one or more images to the face template for the user.

33. A computing device comprising:

a memory;

a camera;

a processor; and

a non-transitory computer readable medium having stored thereon program code which, when executed by the processor, causes the processor to:

receive, from a user, a first indication that the user wishes to authenticate himself or herself with the computing device via face verification;

in response to the first indication, capture, using the camera, a first series of images of the user's face;

authenticate the user by evaluating each of the first series of images against a face template for the user, wherein the user is authenticated based on an N-th image in the first series;

select one or more images from the first series prior to the N-th image by:

calculating a measure of similarity between each of the first series of images and the face template; and

selecting the one or more images based on the measures of similarity; and

add the one or more images to the face template for the user.

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